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(54) REVERSE BIAS HATCHET RESET SPRING

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H01H 3/00 (2006.01)

(52) **U.S. Cl.** **200/400**

(58) **Field of Classification Search** 200/400, 200/401, 500, 501; 218/154; 335/171–179
See application file for complete search history.

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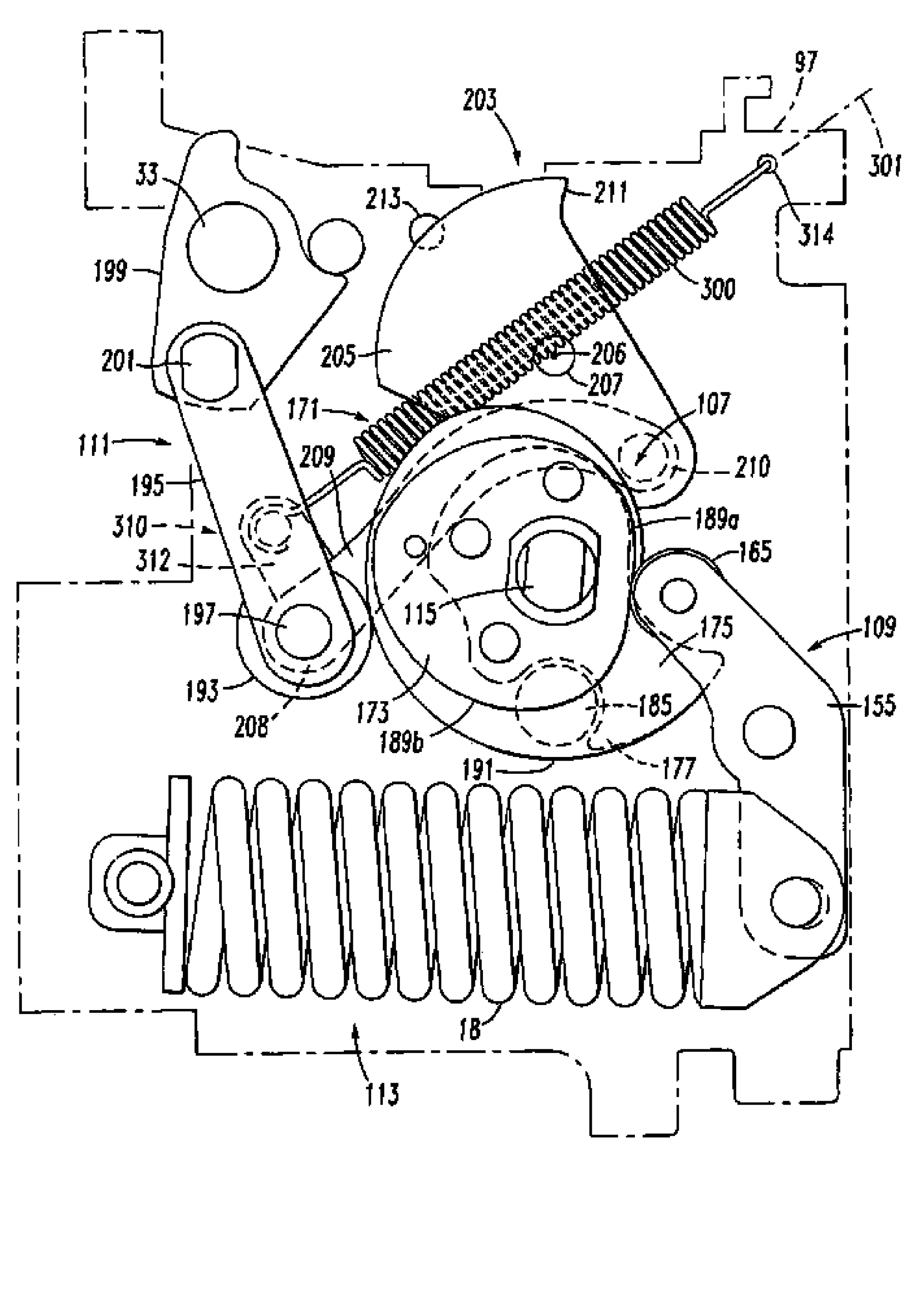
(57) **ABSTRACT**

A spring offset device is structured to extend between a circuit breaker frame assembly and a trip mechanism. The offset device includes an offset member disposed on a trip device banana link, a spring anchor disposed on the frame assembly, and a spring extending between the offset member and the spring anchor. The spring anchor is spaced from the hatchet pin assembly and, preferably positioned so that the longitudinal axis of the spring remains on a single side of a hatchet pin assembly axis as the banana link moves between a closed position, an open position, and a reset position. The offset member and the spring anchor are structured so that, when the hatchet plate is in the closed position, the spring creates an opening force on the hatchet plate biasing the hatchet plate toward the open position, and when the hatchet plate is in the reset position, the spring creates a closing force on the hatchet plate biasing the hatchet plate toward the closed position.

19 Claims, 12 Drawing Sheets



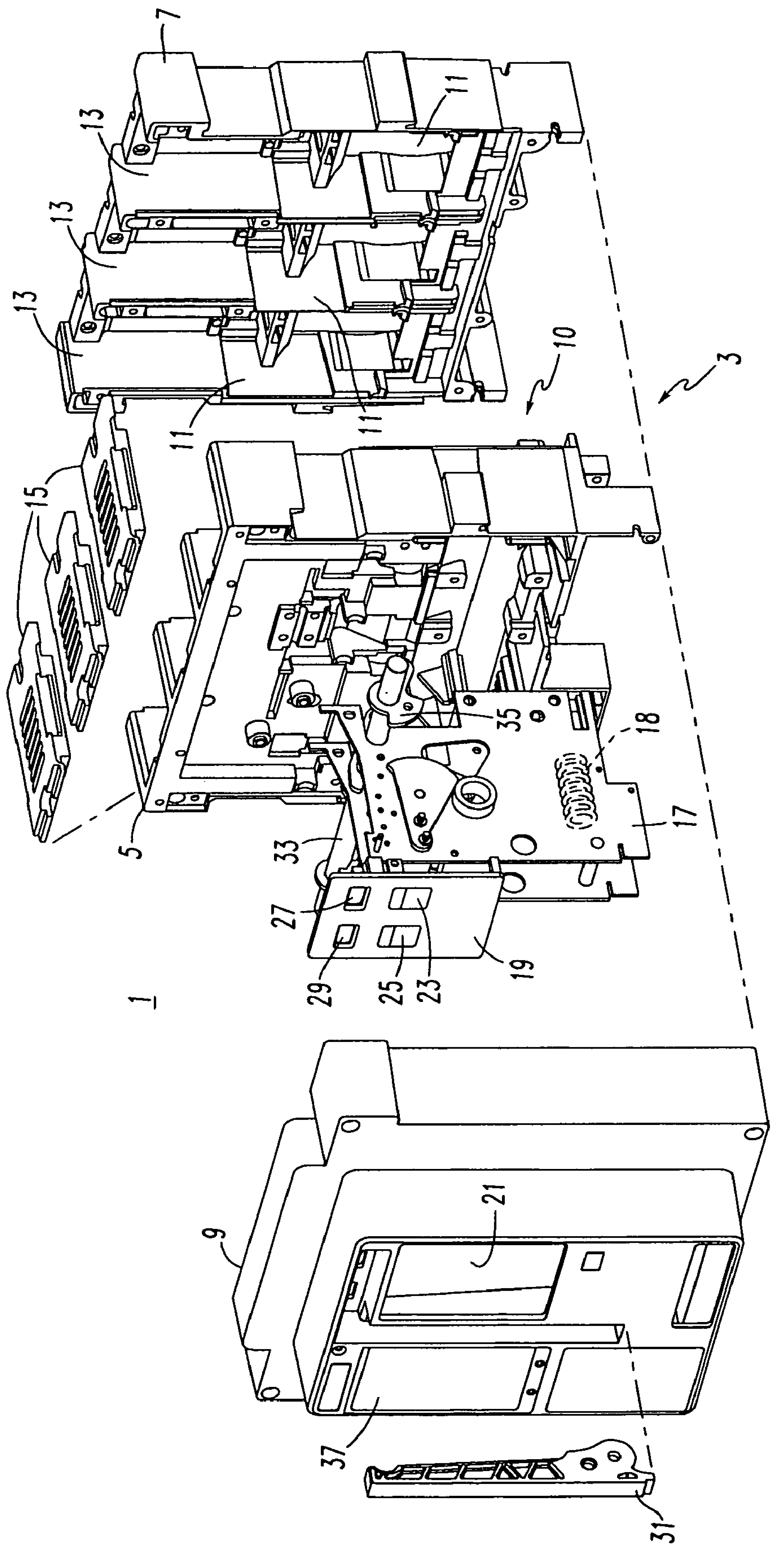


FIG. 1

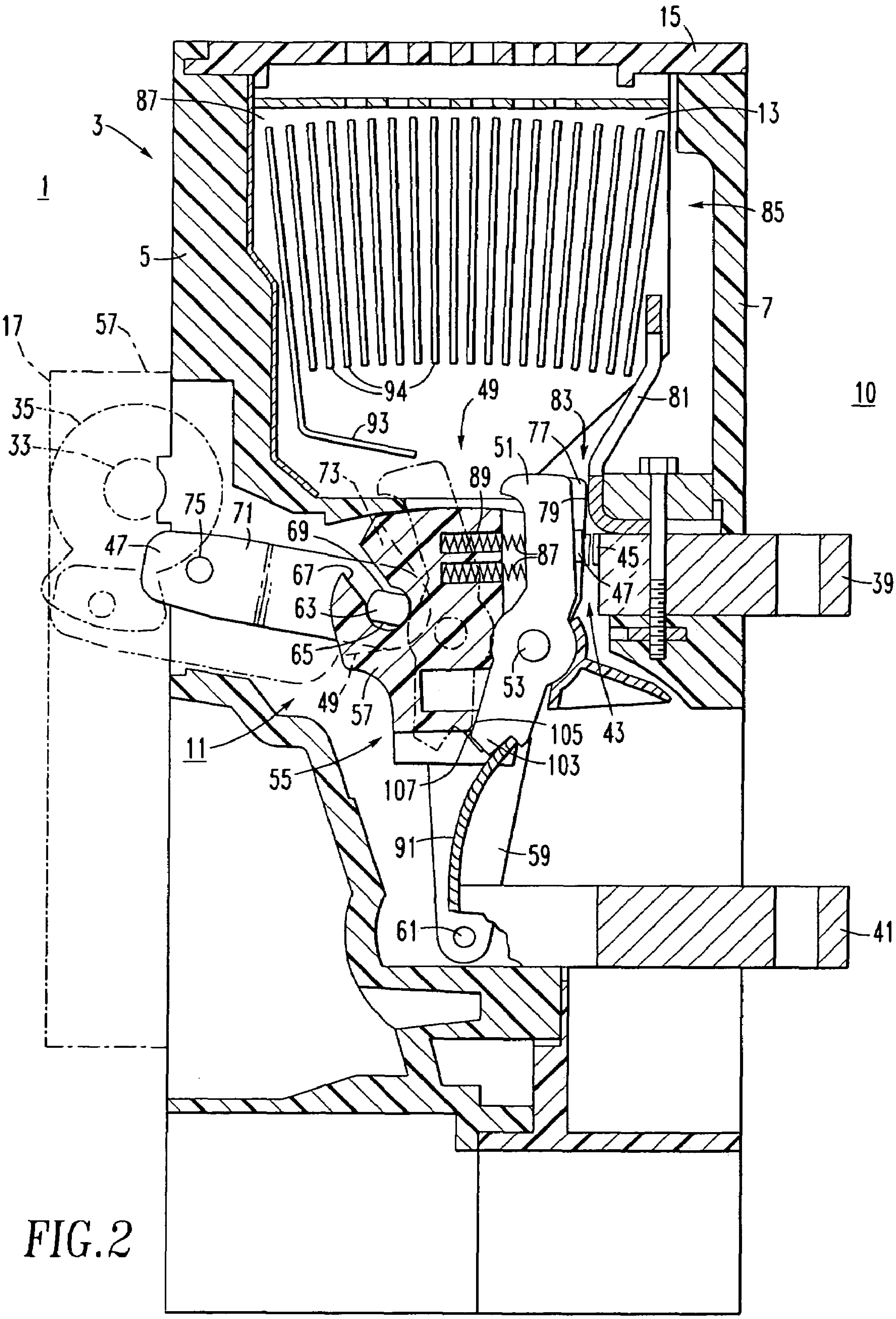

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FIG.2

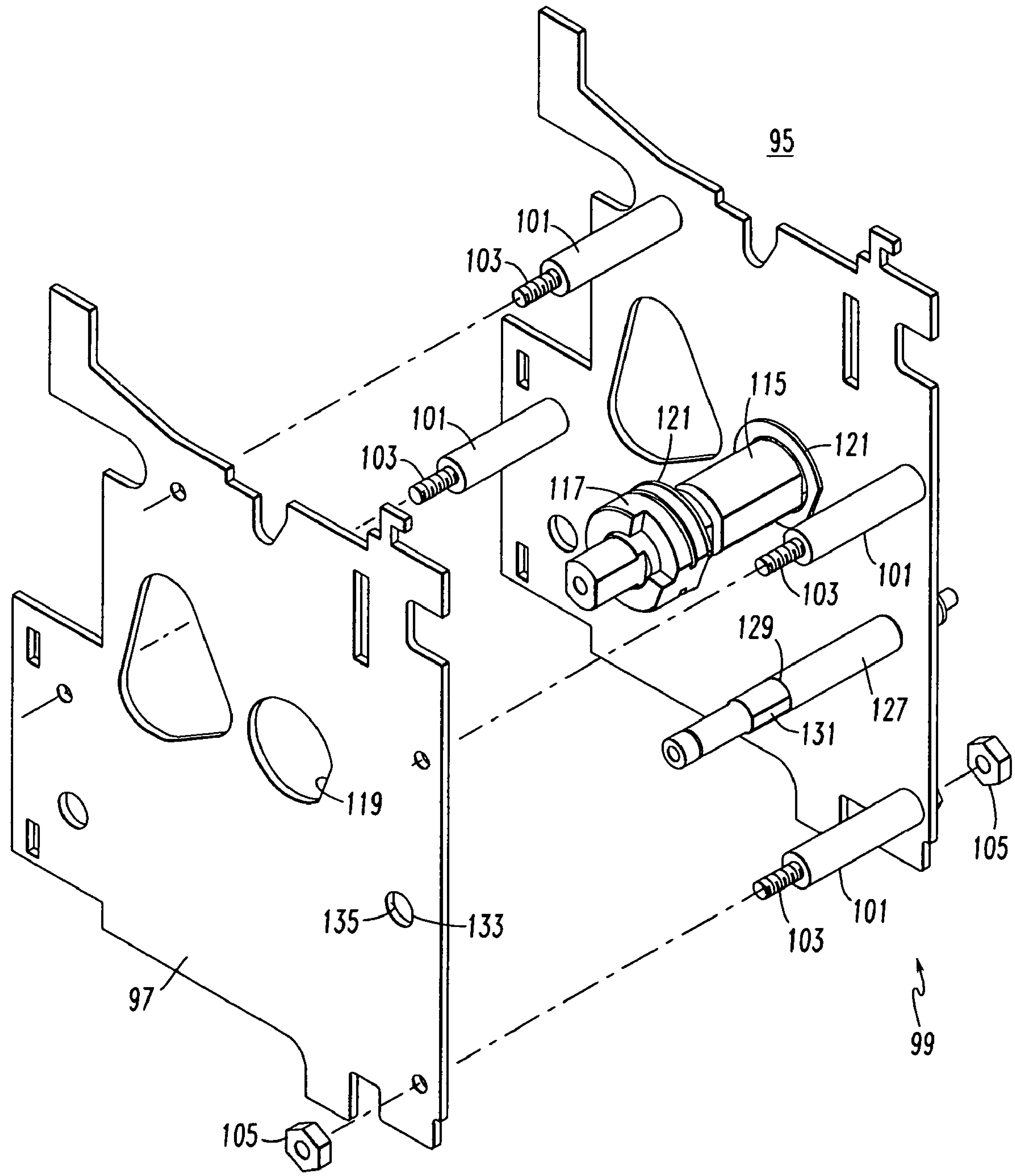
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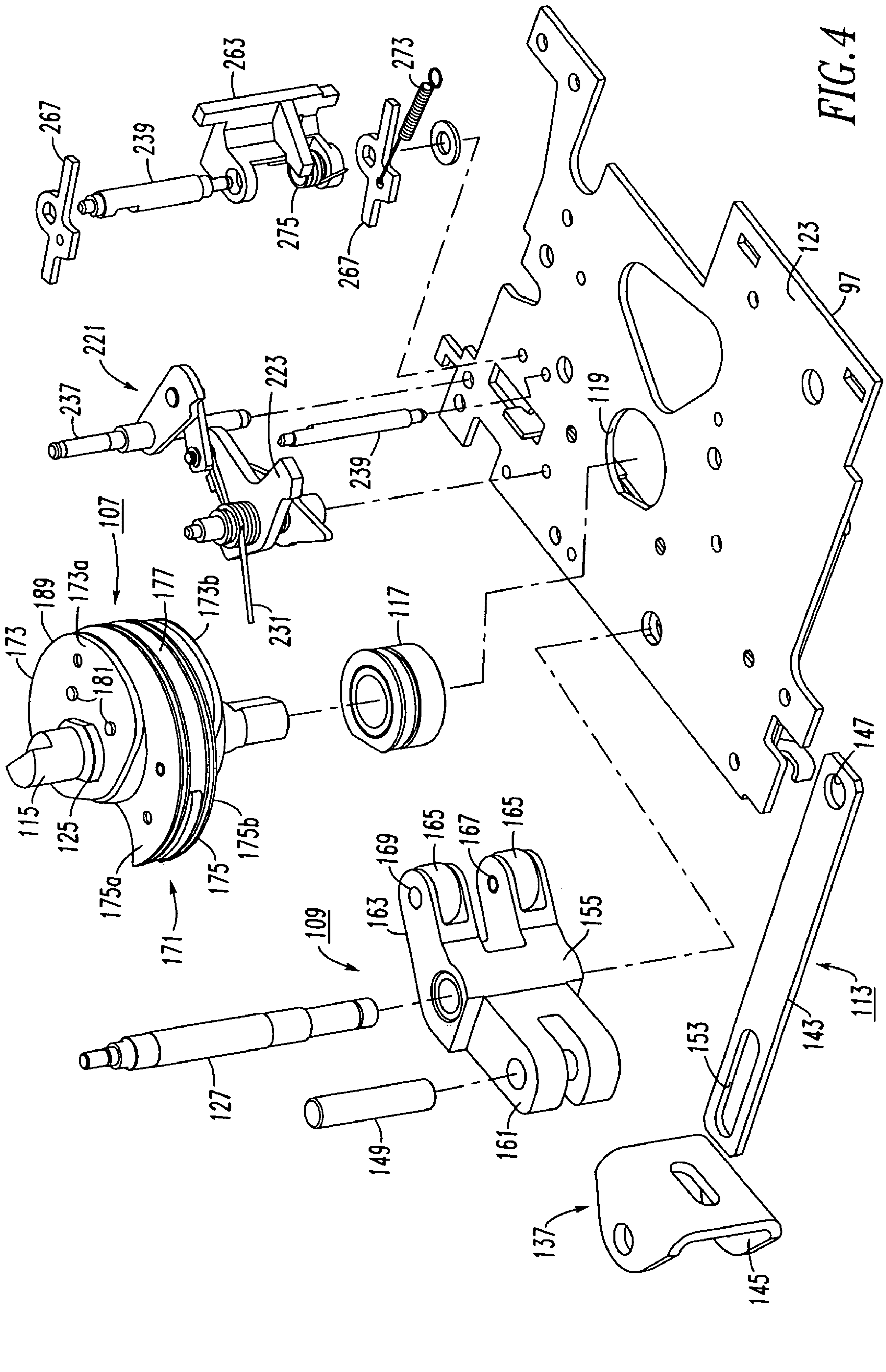
FIG. 3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175a
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175b
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137
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FIG. 4

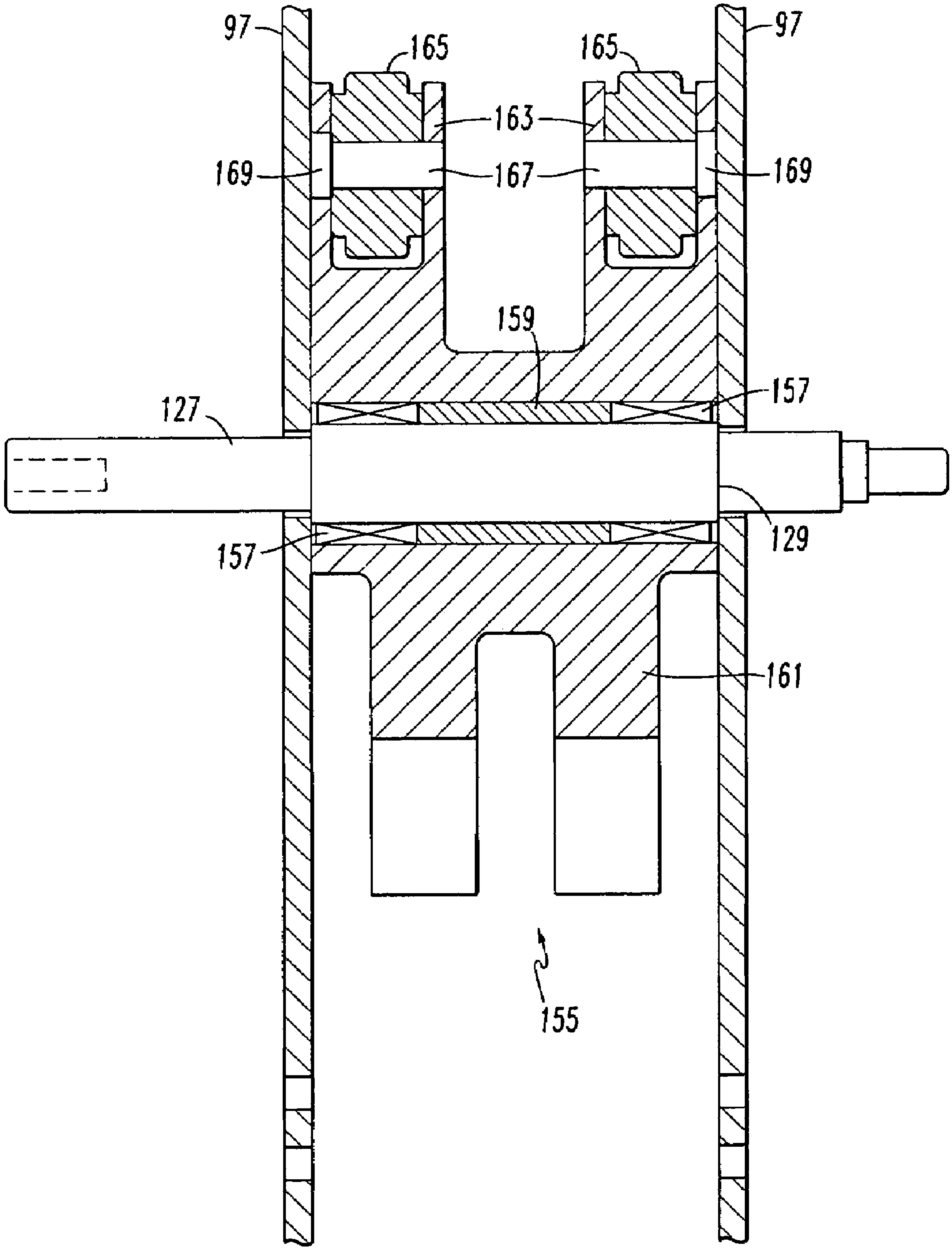

FIG. 5

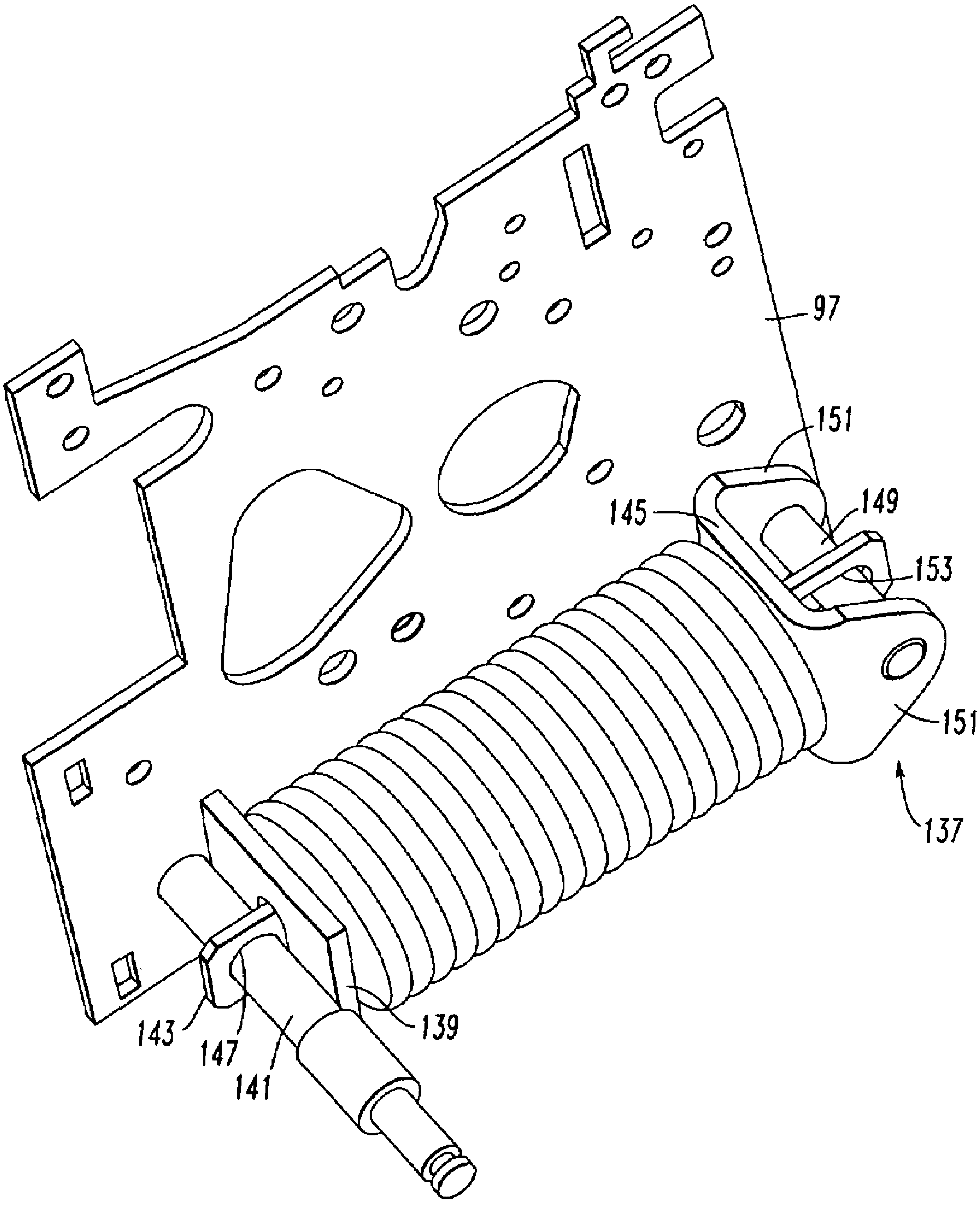

FIG.6

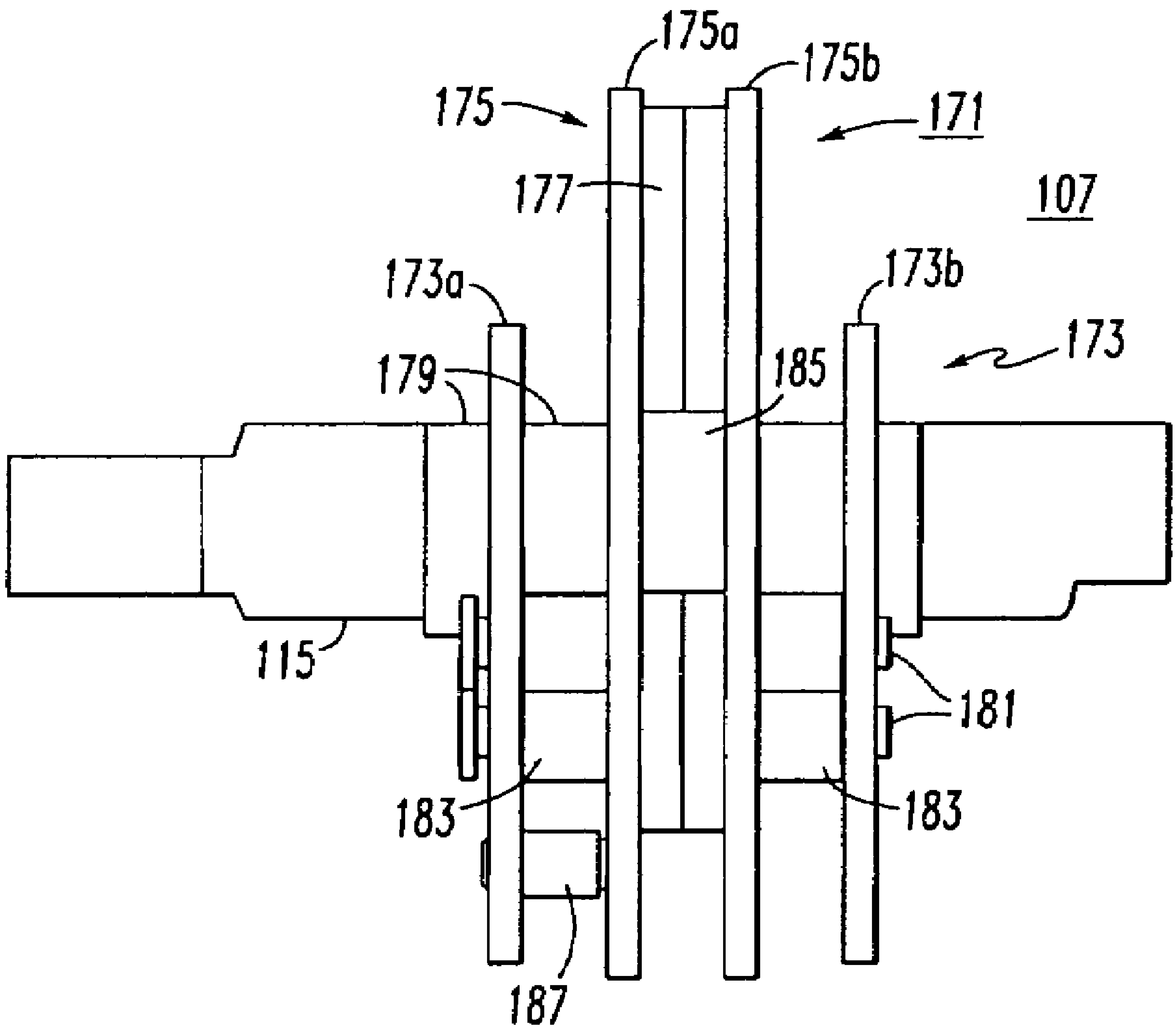
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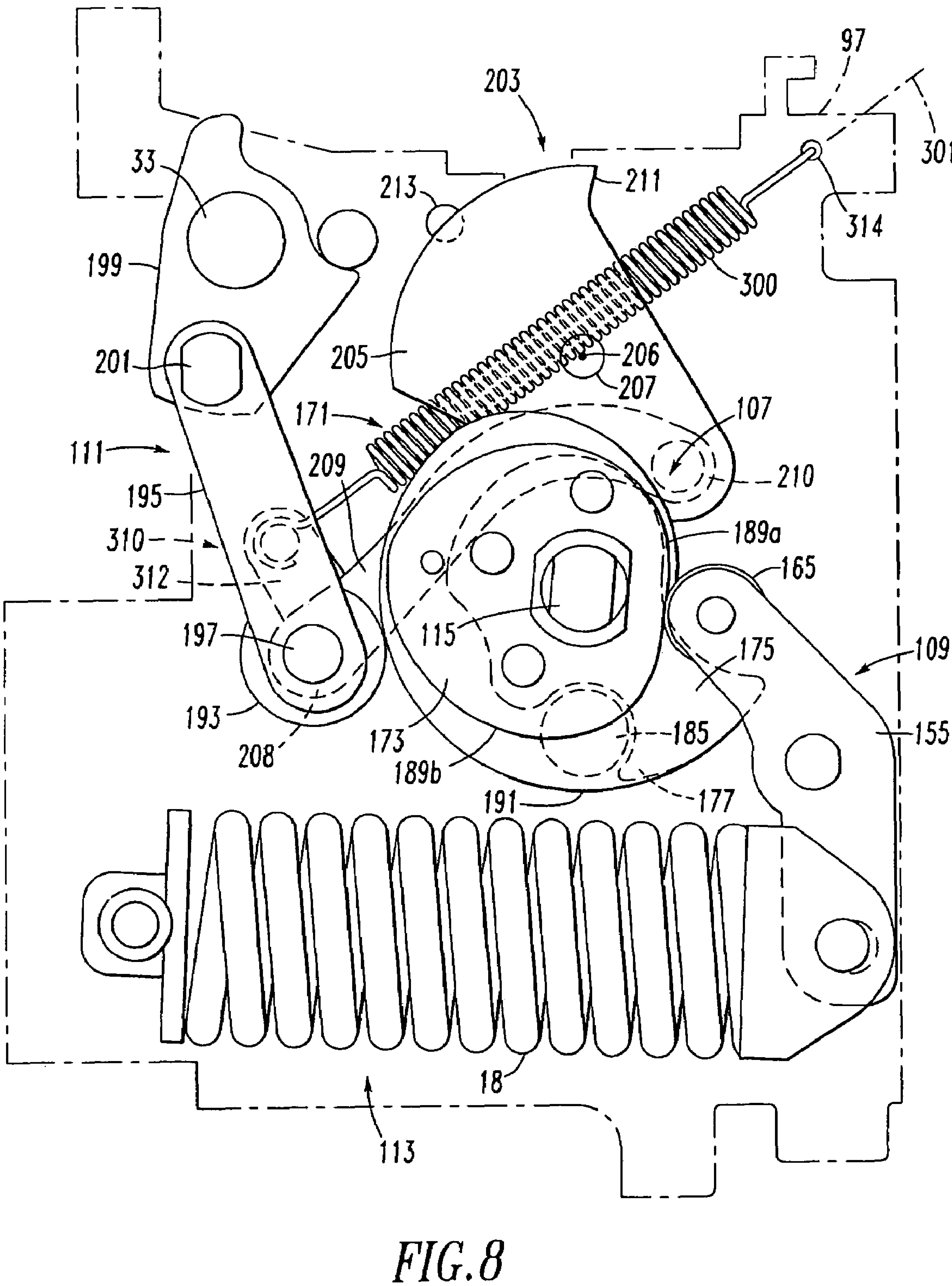
FIG. 7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155
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173
189b
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177
18
113

FIG. 8

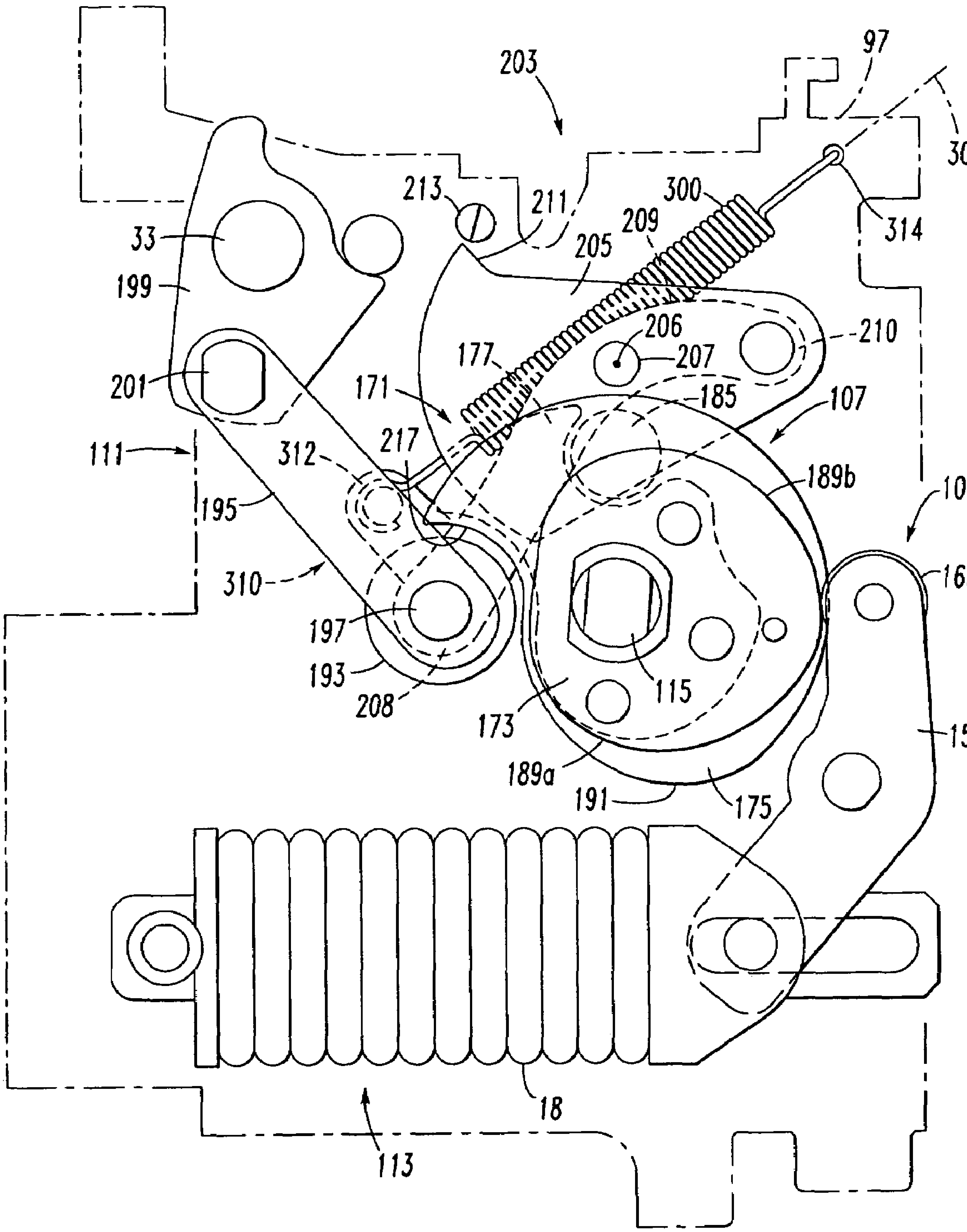
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FIG. 9

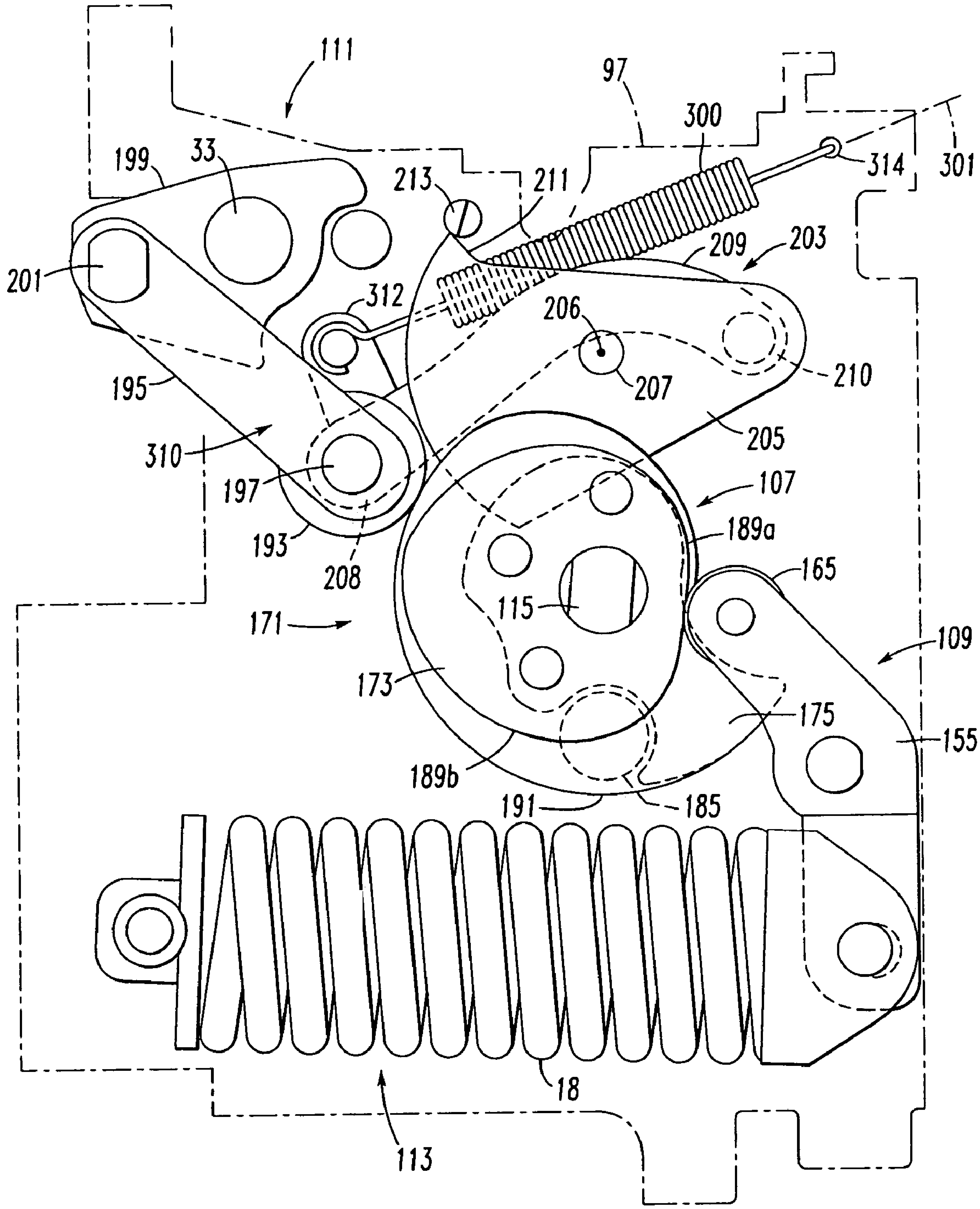
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FIG. 10

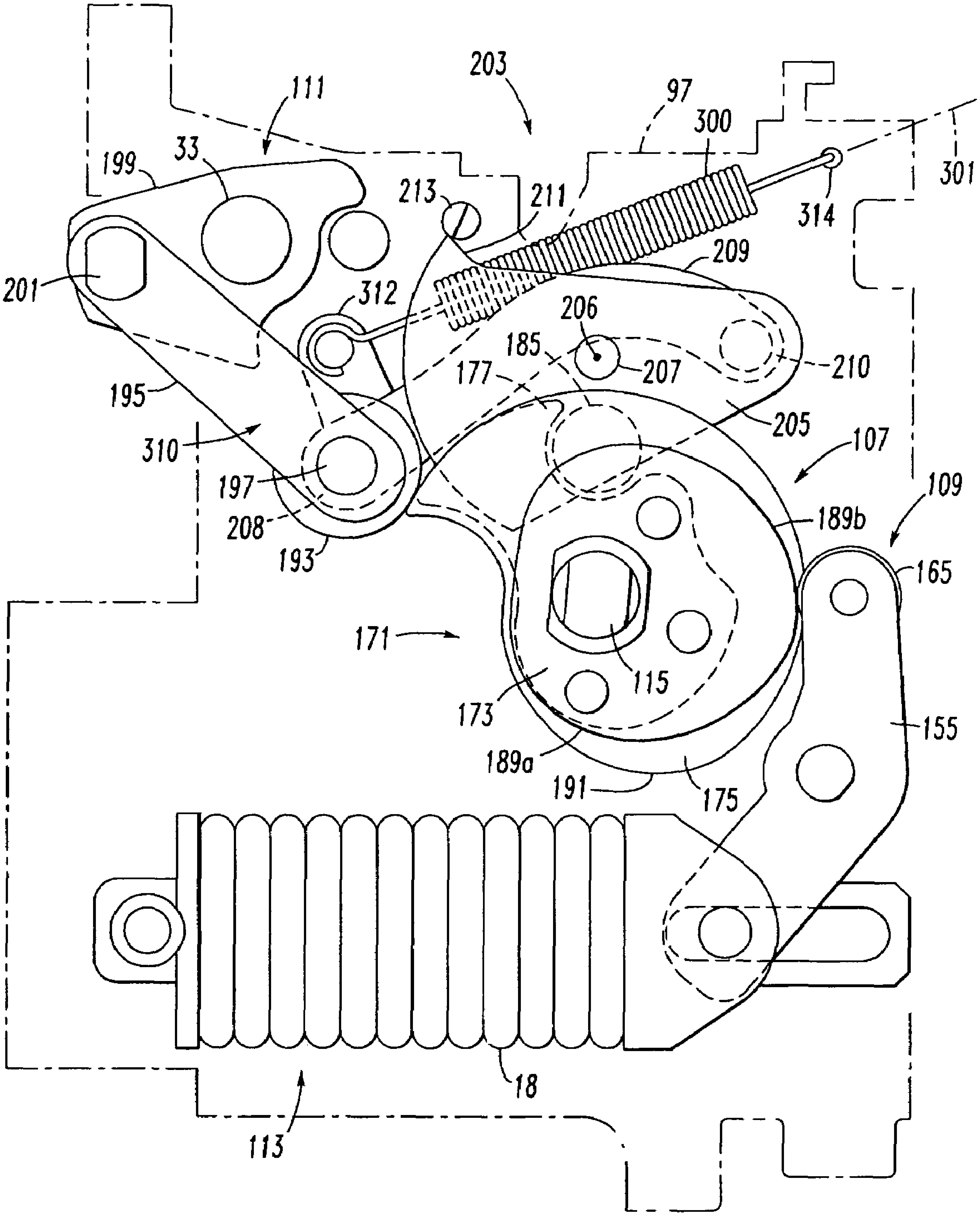

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FIG. 11

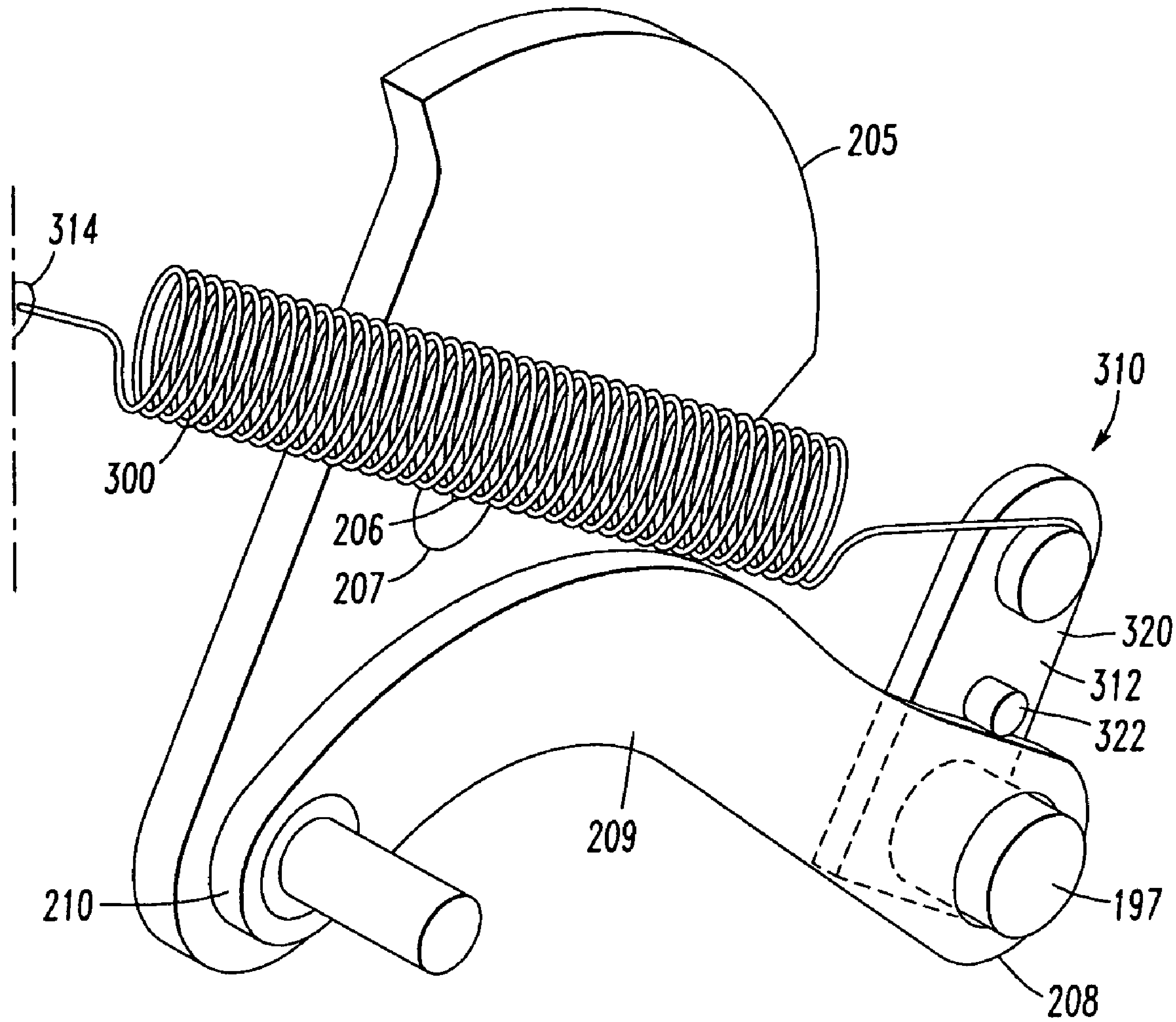

FIG. 12

REVERSE BIAS HATCHET RESET SPRING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a circuit breaker and, more specifically, to a circuit breaker having a trip mechanism with a hatchet plate that is acted upon by a spring so that when the circuit breaker is open the spring biases the hatchet plate toward the rest position and when the circuit breaker is closed the spring biases the hatchet plate toward the trip or open position.

2. Background Information

Electrical switching apparatus for opening and closing electric power circuits typically utilize an energy storage device in the form of one or more large springs to close the contacts of the device into the large currents which can be drawn in such circuits. Such electrical switching apparatus includes power circuit breakers and network protectors which provide protection, and electric switches which are used to energize and deenergize parts of the circuit or to transfer between alternative power sources. These devices also include an open spring which rapidly separates the contacts to interrupt current flowing in the power circuit. Either or both of the close spring and open spring can be a single spring or multiple springs and should be considered as either, even though the singular is hereafter used for convenience. The open spring is charged during closing of the contacts by the close spring which, therefore, must store sufficient energy to both overcome the mechanical and magnetic forces for closing as well as charging the open springs. Moreover, the close spring is required to have sufficient energy to close and latch on at least 15 times the rated current.

The operating mechanism for such circuit breakers typically includes a manual handle, and often an electric motor, for charging the close spring. It also includes a latch mechanism for latching the close spring in the charged state, a release mechanism for releasing the stored energy in the close spring, and an arrangement, a pole shaft for example, for coupling the released energy into the moving conductor assembly supporting the moving contacts of the switch. The operating mechanism has four distinct operational phases, or "conditions," relating to the position of the main contacts, open or closed, and the state of the close spring, discharged or charged. First, there is an open, discharged condition wherein the circuit breaker main contacts are open and the close spring is discharged. To close the main contacts, the close spring is charged resulting in an open, charged condition. After the close spring is actuated, the main contacts are closed and the close spring is discharged resulting in a closed, discharged condition. Finally, the charge spring may be recharged while the main contacts are closed resulting in a closed, charged condition. The operating mechanism does not always pass through each of these conditions in the order set forth above. For example, after the contacts are closed, it is standard practice to charge the close spring again so that the close spring is ready to be used again. If the circuit breaker trips while in the closed, charged condition, the operating mechanism will be moved into the open, charged condition without being in the open, discharged condition.

The operating mechanism includes a latch mechanism. The latch mechanism includes a hatchet plate that is fixed to a hatchet plate pivot pin and structured to move between an open position, a reset position, and a closed position. The status of the hatchet plate is tied to the condition of the operating mechanism, and more specifically to the condition of the main contacts. That is, if the hatchet plate is in the open position, the main contacts will also be in the open condition. When the hatchet plate is in the reset position, the operating mechanism is in the open, charged condition. When the hatchet plate is in the closed position, the main contacts are in the closed condition, although the close spring may be charged or discharged.

The hatchet plate is coupled to the other components of the operating mechanism via a link which, due to its particular shape in the circuit breaker described below, is identified as a "banana link." The hatchet plate is also coupled to a frame assembly via a spring. In prior art, the rest spring was typically attached to the hatchet plate at the banana link pivot pin and biased the hatchet in the reset direction. The disadvantage to this configuration is that the reset bias of the spring tends to prevent tripping of the circuit breaker under unfavorable conditions of high friction and/or low contact force.

There is, therefore, a need for a spring offset device having an offset member, a spring anchor, and a spring extending therebetween structured so that when the circuit breaker is closed, the spring creates a force on the hatchet plate biasing the hatchet plate toward the open, trip position, but when the circuit breaker is open, the spring creates a force on the hatchet plate biasing the hatchet plate toward the reset position.

There is a further need for a spring offset device that may be easily incorporated into presently existing circuit breakers.

SUMMARY OF THE INVENTION

These needs, and others, are met by the present invention which provides a spring offset device structured to extend between a circuit breaker frame assembly and a trip mechanism. The offset device includes an offset member disposed on the banana link, a spring anchor disposed on the frame assembly, and a spring extending between the offset member and the spring anchor. The offset member and the spring anchor are structured so that the force on the offset member is transferred to the banana link through a pin or tab so that the torque on the offset member is transferred directly to the banana link. The spring, acting on the banana link, imparts both a compressive force to the banana link and a torque about its lower pivot pin. The spring creates both a compressive force along the axis of the banana link (a counterclockwise or reset torque) and a force perpendicular to the axis (a clockwise or tripping torque). The tripping torque is relatively constant as the breaker moves from open to closed. But the reset torque reduces dramatically as the axis of the banana link moves closer to the pivot shaft of the hatchet plate. When the breaker is open, the reset torque exceeds the tripping torque and the net torque on the hatchet plate moves it to the reset position. But as the breaker closes and the line of action shifts, the net torque produced by the spring reverses and becomes a tripping torque, which aids the reliable opening of the breaker.

BRIEF DESCRIPTION OF THE DRAWINGS

A full understanding of the invention can be gained from the following description of the preferred embodiments when read in conjunction with the accompanying drawings in which:

FIG. **1** is an exploded isometric view of a low voltage, high current power circuit breaker in accordance with the invention.

FIG. **2** is a vertical section through a pole of the circuit breaker of FIG. **1** shown as the contacts separate during opening.

FIG. **3** is an exploded isometric view of a cage assembly which forms part of the operating mechanism of the circuit.

FIG. **4** is an exploded isometric view illustrating assembly of the operating mechanism.

FIG. **5** is a partial vertical sectional view through an assembled operating mechanism taken through the rocker assembly.

FIG. **6** is an isometric view illustrating the mounting of the close spring which forms part of the operating mechanism.

FIG. **7** is a side elevational view of the cam assembly which forms part of the operating mechanism.

FIG. **8** is an elevation view illustrating the relationship of the major components of the operating mechanism shown with the contacts open and the close spring discharged.

FIG. **9** is a view similar to FIG. **8** shown with the contacts open and the close spring charged.

FIG. **10** is a view similar to FIG. **8** shown with the contacts closed and the close spring discharged.

FIG. **11** is a view similar to FIG. **8** shown with the contacts closed and the close spring charged.

Need: FIG. **12** is an isometric view of one embodiment of the offset device coupled to the banana link.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As used herein, the phrase "disposed on" means "incorporated into" or "coupled with."

As used herein, the phrase "incorporated into" means that two components are unitary or integral to each other such as, but not limited to, a single, cast element or two elements that are fixed together, such as by welding.

As used herein, the phrase "coupled with" means that two components are created as separate elements and are associated with each other either directly or indirectly. For example, a first component that sits on a second component is coupled thereto. Further, a first component and a second component with, for example, a spring extending therebetween are also coupled together.

The invention will be described as applied to a power air circuit breaker; however, it also has application to other electrical switching apparatus for opening and closing electric power circuits. For instance, it has application to switches providing a disconnect for branch power circuits and transfer switches used to select alternate power sources for a distribution system. The major difference between a power circuit breaker and these various switches is that the circuit breaker has a trip mechanism which provides overcurrent protection. The invention could also be applied to network protectors which provide protection and isolation for distribution circuits in a specified area.

This invention may be used with the apparatus disclosed in U.S. Pat. No. 6,072,136, which is incorporated by reference. U.S. Pat. No. 6,072,136 provides a full description of the charging mechanism, as well as various other components of the circuit breaker, which are not relevant to the present invention.

Referring to FIG. **1**, the power air circuit breaker **1** of the invention has a housing **3** which includes a molded front casing **5** and a rear casing **7**, and a cover **9**. The exemplary circuit breaker **1** has three poles **10** with the front and rear casings **5**, **7** forming three, pole chambers **11**. Each pole **10** has an arc chamber **13** which is enclosed by a ventilated arc chamber cover **15**.

Circuit breaker **1** has an operating mechanism **17** which is mounted on the front of the front casing **5** and is enclosed by the cover **9**. The operating mechanism **17** has a face plate **19** which is accessible through an opening **21** in the cover. The operating mechanism **17** includes a large close spring **18** which is charged to store energy for closing the circuit breaker **1**. Face plate **19** mounts a push to close button **23** which is actuated to discharge the close spring **18** for closing the circuit breaker **1**, and a push to open button **25** for opening the circuit breaker **1**. Indicators **27** and **29** display the condition of the close spring **18** and the open/closed state of the contacts, respectively. The close spring **18** is charged by operation of the charging handle **31** or remotely by a motor operator (not shown).

The common operating mechanism **17** is connected to the individual poles **10** by a pole shaft **33** with a lobe **35** for each pole **10**. As is conventional, the circuit breaker **1** includes an electronic trip unit **37** supported in the cover **9** which actuates the operating mechanism **17** to open all of the poles **10** of the circuit breaker **1** through rotation of the pole shaft **33** in response to predetermined characteristics of the current flowing through the circuit breaker **1**.

FIG. **2** is a vertical section through one of the pole chambers **11**. The pole **10** includes a line side conductor **39** which projects out of the rear casing **7** for connection to a source of ac electric power (not shown). A load conductor **41** also projects out of the rear casing **7** for connection typically to the conductors of the load network (also not shown).

Each pole **10** also includes a pair of main contacts **43** that include a stationary main contact **45** and a moveable main contact **47**. The moveable main contact **47** is carried by a moving conductor assembly **49**. This moving conductor assembly **49** includes a plurality of contact fingers **51** which are mounted in spaced axial relation on a pivot pin **53** secured in a contact carrier **55**. The contact carrier **55** has a molded body **57** and a pair of legs **59** (only one shown) having pivots **61** rotatably supported in the housing **3**.

The contact carrier **55** is rotated about the pivots **61** by the operating mechanism **17** which includes a drive pin **63** received in a transverse passage **65** in the carrier body **57** through a slot **67** to which the drive pin **63** is keyed by flats **69**. The drive pin **63** is fixed on a drive link **71** which is received in a groove **73** in the carrier body. The other end of the drive link **71** is pivotally connected by a pin **75** to the associated lobe arm **35** on the pole shaft **33** similarly connected to the carriers (not shown) in the other poles of the circuit breaker **1**. The pole shaft **33** is rotated by the operating mechanism **17**.

A moving main contact **47** is fixed to each of the contact fingers **51** at a point spaced from the free end of the finger **51**. The portion of the contact finger **51** adjacent the free end forms a moving arcing contact or "arc toe" **77**. A stationary arcing contact **79** is provided on the confronting face of an integral arcing contact and runner **81** mounted on the line side conductor **39**. The stationary arcing contact **79** and arc toe **77** together form a pair of arcing contacts **83**. The integral arcing contact **83** and runner **81** extends upward toward a conventional arc chute **85** mounted in the arc chamber **13**.

The contact fingers **51** are biased clockwise as seen in FIG. **2** on the pivot pin **53** of the carrier **55** by pairs of helical compression springs **87**, the "open springs," seated in recesses **89** in the carrier body **57**. The operating mechanism **17** rotates the pole shaft **33** which, in turn, pivots the contact carrier **55** clockwise to a closed position (not shown) to close the main contacts **43**. To open the contacts **43**, the operating mechanism **17** releases the pole shaft **33** and the compression springs **87** accelerate the carrier **55** in a counterclockwise direction to an open position (not shown). As the carrier **55** is rotated clockwise toward the closed position, the arc toes **77** contact the stationary arcing contacts **79** first. As the carrier **55** continues to move clockwise, the compression springs **87** compress as the contact fingers **51** rock about the pivot pin **53** until the main contacts **43** close. Further clockwise rotation to the fully closed position (not shown) results in opening of the arcing contacts **83** while the main contacts **43** remain closed. In that closed position, a circuit is completed from the line side conductor **39** through the closed main contacts **43**, the contact fingers **51**, flexible shunts **91**, and the load conductor **41**.

To open the circuit breaker **1**, the operating mechanism **17** releases the pole shaft **33** so that the compressed springs **87** accelerate the carrier **55** counterclockwise as viewed in FIG. **2**. Initially, as the carrier **55** moves away from the line side conductor **39**, the contact fingers **51** rock so that the arcing contacts **83** close while the main contacts **43** remain closed. As the carrier **55** continues to move counterclockwise, the main contacts **43** open and all of the current is transferred to the arcing contacts **83** which is the condition shown in FIG. **2**. If there is a sizeable current being carried by the circuit breaker **1** such as when the circuit breaker **1** trips open in response to an overcurrent or short circuit, an arc is struck between the stationary arcing contacts **79** and the moveable arcing contacts or arc toes **77** as these contacts separate with continued counterclockwise rotation of the carrier **55**. As the main contacts **43** have already separated, the arcing is confined to the arcing contacts **83** which preserves the life of the main contacts **43**. The electromagnetic forces produced by the current sustained in the arc push the arc outward toward the arc chute **85** so that the end of the arc at the stationary contact **79** moves up the integral arcing contact **83** and runner **81** and into the arc chute **85**. At the same time, the rapid opening of the carrier **55** brings the arc toes **77** adjacent the free end of the arc top plate **93** as shown in phantom in FIG. **2** so that the arc extends from the arc toes **77** to the arc top plate **93** and moves up the arc top plate **93** into the arc plates **94** which break the arc up into shorter sections which are then extinguished.

The operating mechanism **17** is a self supporting module having a frame assembly **95**. As shown in FIG. **3**, the frame assembly **95** includes two side plates **97** which are identical and interchangeable. The side plates **97** are held in spaced relation by four elongated members **99** formed by spacer sleeves **101**, and threaded shafts **103** and nuts **105** which clamp the side plates **97** against the spacer sleeves **101**. Four major subassemblies and a large close spring **18** make up the power portion of the operating mechanism **17**. The four major subassemblies are the cam assembly **107**, the rocker assembly **109**, the main link assembly **111** and a close spring support assembly **113**. All of these components fit between the two side plates **97**. Referring to FIGS. **3** and **4**, the cam assembly **107** includes a cam shaft **115** which is journaled in a non-cylindrical bushing **117** which are seated in complementary non-cylindrical openings **119** in the side plates **97**. The bushing **117** has a flange **121** which bears against the inner face **123** of the side plate **97**, and the cam shaft **115** has shoulders **125** which position it between the bushing **117** and the collar **222** so that the cam shaft **115** and the bushing **117** are captured between the side plates **97** without the need for fasteners. Similarly, a rocker pin **127** of the rocker assembly **109** has shoulders **129** which capture it between the side plates **97** as seen in FIGS. **3**-**5**. Flats **131** on the rocker pin **127** engage similar flats **133** in openings **135** in the side plates **97** to prevent rotation of the rocker pin **127**. The cam shaft **115** and rocker pin **127** add stability to the frame assembly **95** which is self-aligning and needs no special fixturing for alignment of the parts during assembly. As the major components are "sandwiched" between the two side plates **97**, the majority of the components need no additional hardware for support. As will be seen, this sandwich construction simplifies assembly of the operating mechanism **17**.

The close spring **18** is a common, round wire, heavy duty, helical compression spring **87** closed and ground flat on both ends. A compression spring **87** is used because of its higher energy density than a tension spring. The helical compression close spring **18** is supported in a very unique way by the close spring support assembly **113** in order to prevent stress risers and/or buckling. In such a high energy application, it is important that the ends of the close spring **18** be maintained parallel and uniformly supported and that the spring **18** be laterally held in place. As illustrated particularly in FIGS. **4** and **6**, and also in FIGS. **8**-**11**, this is accomplished by compressing the helical compression close spring **18** between a U-bracket **137** which is free to rotate and also drive the rocker assembly **109** at one end, and a nearly square spring washer or guide plate **139** which can pivot against a spring stop or support pin **141** which extends between the slide plates **97** at the other end. The close spring **18** is kept from "walking" as it is captured between the two side plates **97**, and is laterally restrained by an elongated guide member **143** that extends through the middle of the spring **18**, the guide plate **139** and the brace **145** of the U-bracket **137**. The elongated guide member **143**, in turn, is captured on one end by the support pin **141** which extends through an aperture **147**, and on the other end by a bracket pin **149** which extends through legs **151** on the U-bracket **137** and an elongated slot **153** in the elongated member **143**.

The rocker assembly **109** includes a rocker **155** pivotally mounted on the rocker pin **127** by a pair of roller bearings **157** which are captured between the side plates **97** and held in spaced relation by a sleeve **159** as best seen in FIG. **5**. The rocker **155** has a clevis **161** on one end which pivotally connects the rocker **155** to the U-bracket **137** through the bracket pin **149**. A pair of legs **163** on the other end of the rocker **155** which extend at an obtuse angle to the clevis **161**, form a pair of roller devises which support rocker rollers **165**. The rocker rollers **165** are pivotally mounted to the roller clevises **161** by pins **167**. These pins **167** have heads **169** facing outwardly toward the side plates **97** so that they are captured and retained in place without the need for any snap rings or other separate retainers. As the rocker **155** rocks about the rocker pin **127**, the guide plate **139** rotates on the spring support pin **141** so that the loading on the close spring **18** remains uniform regardless of the position of the rocker **155**. The close spring **18**, guide plate **139** and spring support pin **141** are the last items that go into an operating mechanism **17** so that the close spring **18** can be properly sized for the application.

The U-bracket pin **149** transfers all of the spring loads and energy to the rocker clevis **161** on the rocker **155**. The translational loads on the rocker **155** are transferred into the non-rotating rocker pin **127** and from there into the two side plates **97** while the rocker **155** remains free to rotate between the side plates **97**.

Referring to FIGS. **4**-**11**, the cam assembly **107** includes, in addition to the cam shaft **115**, a cam member **171**. The cam member **171** includes a charge cam **173** formed by a pair of charge cam plates **173***a*, **173***b* mounted on the cam shaft **115**. The charge cam plates **173***a*, **173***b* straddle a drive cam **175** which is formed by a second pair of cam plates **175***a*, **175***b*. A cam spacer **177** sets the spacing between the drive cam plates **175***a*, **175***b* while spacer bushings **179** separate the charge cam plates **173***a*, **173***b* from the drive cam plates **175***a*, **175***b* and from the side plates **97**. The cam plates **173***a*, **173***b*, **175***a*, **175***b* are all secured together by rivets **181** extending through rivet spacers **183** between the plates **97**. A stop roller **185** is pivotally mounted between the drive cam plates **175***a* and **175***b* and a reset pin **187** extends between the drive cam plate **175***a* and the charge cam plate **173***a*. The cam assembly **107** is a 360° mechanism which compresses the close spring **18** to store energy during part of the rotation, and which is rotated by release of the energy stored in the close spring **18** during the remainder of rotation. This is accomplished through engagement of the charge cam plates **173***a*, **173***b* by the rocker rollers **165**. The preload on the close spring **18** maintains the rocker rollers **165** in engagement with the charge cam plates **173***a*, **173***b*. The charge cam **173** has a cam profile **189** with a charging portion **189***a* which at the point of engagement with the rocker rollers **165** increases in diameter with clockwise rotation of the cam member **171**. The cam shaft **115** and therefore the cam member **171** is rotated either manually by the charging handle **31** or by an electric motor (not shown). The charging portion **189***a* of the charge cam profile **189** is configured so that a substantially constant torque is required to compress the close spring **18**. This provides a better feel for manual charging and reduces the size of the motor required for automatic charging as the constant torque is below the peak torque which would normally be required as the spring **18** approaches the filly compressed condition.

The cam profile **189** on the charge cam **173** also includes a closing portion **189***b* which decreases in diameter as the charge cam **173** rotates against the rocker rollers **165** so that the energy stored in the close spring **18** drives the cam member **171** clockwise when the mechanism is released.

The drive cam **175** of the cam member **171** has a cam profile **191** which, in certain rotational positions, is engaged by a drive roller **193** mounted on a main link **195** of the main link assembly **111** by a roller pin **197**. The other end of the main link **195** is pivotally connected to a drive arm **199** on the pole shaft **33** by a pin **201**. This main link assembly **111** is coupled to the drive cam **175** for closing the circuit breaker **1** by a trip mechanism **203** which includes a hatchet plate **205** pivotally mounted on a hatchet pivot pin assembly **207** supported by the side plates **97**, and biased counter-clockwise by a spring **300**, as detailed below. A banana link **209** is an elongated member which, in this embodiment has a slightly curved shape. The banana link **209** has a first end **208** and a second end **210**. The banana link first end **208** is pivotally connected to an extension on the roller pin **197** of the main link assembly **111**. The banana link second end **210** is pivotally connected to one end of the hatchet plate **205**. The other end of the hatchet plate **205**, that is, on the opposite side of the hatchet plate **205** pivot point, as described below, has a latch ledge **211** which engages a trip D shaft **213** when the shaft is rotated to a latch position. With the hatchet plate **205** latched, the banana link **209** holds the drive roller **193** in engagement with the drive cam **175**. In operation, when the trip D shaft **213** is rotated to a trip position, the latch ledge **211** slides off of the trip D shaft **213** and the hatchet plate **205** passes through a notch **215** in the trip D shaft **213** which repositions the pivot point of the banana link **209** connected to the hatchet plate **205** and allows the drive roller **193** to float independently of the drive cam **175**.

The sequence of charging and discharging the close spring **18** can be understood by reference to FIGS. **8-11**. It should be understood that there are two conditions for two components; the close spring **18** which may be charged or discharged, and the main contacts **43** which may be open or closed. Thus, FIGS. **8-11** show the four combinations of these conditions. That is, in FIG. **8**, the main contacts **43** (not shown) are in the open position and the close spring **18** is discharged. In FIG. **9**, the close spring **18** is charged and the main contacts **43** (not shown) remain open. In FIG. **10**, the close spring **18** has been discharged to close the main contacts **43** (not shown). Finally, in FIG. **11**, the main contacts **43** (not shown) remain closed and the close spring **18** has been charged. A detailed description of the sequence to charge the close spring **18**, close the main contacts **43**, and charge the close spring **18** again follows.

In FIG. **8**, the mechanism is shown in the discharged open position, that is, the close spring **18** is discharged and the main contacts **43** are open. It can be seen that the cam member **171** is positioned so that the charge cam **173** has its smallest radius in contact with the rocker rollers **165**. Thus, the rocker **155** is rotated to a full counterclockwise position and the close spring **18** is at its maximum extension. It can also be seen that the trip mechanism **203** is not latched so that the drive roller **193** is floating although resting against the drive cam **175**. As the cam shaft **115** is rotated clockwise manually by the charging handle **31** or through operation of the charge motor (not shown) the charge portion **189***a* of the charge profile on the charge cam **173** which progressively increases in diameter, engages the rocker roller **165** and rotates the rocker **155** clockwise to compress the spring **18**. As mentioned, the configuration of this charge portion **189***a* of the profile **189** is selected so that a constant torque is required to compress the spring **18**. During this charging of the close spring **18**, the driver roller **193** is in contact with a portion of the drive cam profile **191** which has a constant radius so that the drive roller **193** continues to float.

Moving now to FIG. **9**, as the close spring **18** becomes fully charged, the drive roller **193** falls off of the drive cam profile **191** into a recess **217**. This permits the reset spring **300** to rotate the hatchet plate **205** counterclockwise until the latch ledge **211** passes slightly beyond the trip D shaft **213**. This raises the pivot point of the banana link **209** on the hatchet plate **205** so that the drive roller **193** is raised to a position where it rests beneath the recess **217** in the drive cam **175**. At the same time, the rocker rollers **165** reach a point just after 170° rotation of the cam member **171** where they enter the charge portion **189***a* of the charge cam profile **189**. On this portion **189***a* of the charge cam profile **189**, the radius of the charge cam **173** in contact with the rocker rollers **165** decreases in radius with clockwise rotation of the cam member **171**. Thus, the close spring **18** applies a force tending to continue rotation of the cam member **171** in the clockwise direction. However, a close prop (not shown in FIG. **9**) which is part of a close prop mechanism, described fully in U.S. Pat. No. 6,072,136, engages the stop roller **185** and prevents further rotation of the cam member **171**. Thus, the close spring **18** remains fully charged ready to close the main contacts **43** of the circuit breaker **1**.

The main contacts **43** of the circuit breaker **1** are closed by release of the close prop. With the close prop disengaged from the stop roller **185**, the spring energy is released to rapidly rotate the cam member **171** to the position shown in FIG. **10**. As the cam member **171** rotates, the drive roller **193** is engaged by the cam profile **191** of the drive cam **175**. The radius of this cam profile **191** increases with cam shaft **115** rotation and since the banana link **209** holds the drive roller **193** in contact with this surface, the pole shaft **33** is rotated to close the main contacts **43** as described in connection with FIG. **2**. At this point the latch ledge **211** engages the trip D latch **213** and the main contacts **43** are latched closed. If the circuit breaker **1** is tripped at this point by rotation of the trip D shaft **213** so that this latch ledge **211** is disengaged from the trip D shaft **213**, the very large force generated by the compression springs **87** (see FIG. **2**) exerted through the main link **195** pulls the pivot point of the banana link **209** on the hatchet plate **205** clockwise downward as the hatchet plate **205** rotates about the hatchet pin assembly **207** (See FIG. **8**) and the drive roller **193** drops free of the drive cam **175** allowing the pole shaft **33** to rotate and the main contacts **43** to open. With the main contacts **43** open and the close spring **18** discharged the mechanism would again be in the state shown in FIG. **8**.

Typically, when the circuit breaker **1** is closed, the close spring **18** is recharged, again by rotation of the cam shaft **115** either manually or electrically. This causes the cam member **171** to return to the same position as in FIG. **9**, but with the trip mechanism **203** latched, the banana link **209** keeps the drive roller **193** engaged with the drive cam profile **191** on the drive cam **175** as shown in FIG. **11**. If the circuit breaker **1** is tripped at this point by rotation of the trip D latch **213** so that the hatchet plate **205** rotates clockwise, the drive roller **193** will drop down into the recess **217** in the drive cam **175** and the circuit breaker **1** will open.

The hatchet plate **205** and the banana link **209** move through three corresponding positions during the sequence of charging and discharging the close spring **18** as shown in FIG. **8**-**11**. As shown in FIG. **8**, the hatchet plate **205** and the banana link **209** are in an "open position" wherein the hatchet plate **205** does not engage the D shaft **213** and the hatchet plate **205** is disposed within a notch **215** in the trip D shaft **213** as described above. As set forth in U.S. Pat. No. 6,072,136, the hatchet plate **205** is only in this position after the trip D shaft **213** has been rotated which also causes the main contacts **43** to separate into the open condition. Thus, this position is identified as the "open position" of both the hatchet plate **205** and the banana link **209**.

As shown in FIG. **9**, and as described above, after the charging of the close spring **18**, the hatchet plate **205** has been rotated counter-clockwise about the hatchet pin assembly **207** and the banana link **209**, by virtue of the coupling of the banana link second end **210** to the hatchet plate **205**, has rotated counter-clockwise about the banana link first end **208**. In the configuration shown in FIG. **9**, the hatchet plate **205** and the banana link **209** are in a "reset position" wherein the hatchet plate **205** does not engage the trip D shaft **213** but the hatchet plate **205** has moved out of the notch **215** in the trip D shaft **213** and the latch ledge **211** is adjacent to the D shaft **213**. Additionally, the trip D shaft **213** has rotated to the latch position as described above.

When the main contacts **43** are closed by discharging the close spring **18**, the hatchet plate **205** and the banana link **209** are moved into the "closed position." As shown in FIGS. **10** and **11**. In this position, the hatchet plate **205** has rotated slightly clockwise about the hatchet pin assembly **207** so that the latch ledge **211** engages the trip D shaft **213**.

The interaction of the hatchet plate **205**, the banana link **209** and the reset spring **300** are as follows: The reset spring **300** creates both a compression force in the banana link **209**, which creates a reset torque on the hatchet plate **205**, and a moment on the banana link **209**, which in turn creates a tripping moment on the hatchet plate **205**. Since the end of the banana link **209** moves when the circuit breaker **1** closes, this movement can be used to reverse the net torque on the hatchet plate **205** created by the reset spring **300**. The direction of forces acting on the components may be controlled by providing a spring offset device **310** as shown in best in FIG. **12**. The spring offset device **310** includes an offset member **312** and a spring anchor **314**. The spring **300** is coupled to, and extends between, the offset member **312** and spring anchor **314**. The location of the offset member **312** and a spring anchor **314** relative to the hatchet pivot pin assembly **207** controls the influence of the spring **300** on the hatchet plate **205** and the banana link **209**. The offset member **312** is disposed on, or adjacent to, the banana link first end **208**. The spring anchor **314** is disposed on a frame assembly side plate **97** and spaced from said hatchet pin assembly **207**. As described above, the hatchet plate **205** is structured to move within a plane. The hatchet pin assembly **207** has an axis of rotation **206** that extends generally perpendicular to the hatchet plate **205** plane of movement. The spring **300** has a longitudinal axis **301**. The spring longitudinal axis **301** remains on a single side of the hatchet pin assembly axis **206** as said banana link **209** moves between said closed position and said open position. In this configuration, when said hatchet plate **205** is in the closed position, the spring **300** creates an opening force on hatchet plate **205** that biases the hatchet plate **205** toward the open position, and when the hatchet plate **205** is in the reset position, the spring **300** creates a closing force on the hatchet plate **205** that biases the hatchet plate **205** toward the closed position. Thus, the spring **300** acts to bias the hatchet plate **205** in the desired direction of rotation.

When the spring **300** biases the hatchet plate **205** to the open position, the force on the hatchet plate **205** is an opening force. When the spring **300** biases the hatchet plate **205** to the closed position, the force on the hatchet plate **205** is a closing force. The force acting on the hatchet plate **205** created by the spring **300** (F_S) may be calculated as follows. It is noted that, typically, there are other forces acting on the hatchet plate **205** as well. The downward reaction force (F_R) on the pin which connects the banana link **209** to the hatchet plate **205**, by taking the balance of moments on the banana link **209** about the lower pin, may be expressed as follows:

$$F_R = F_S\,(L_{lever}/L_B)$$

Taking a sum of moments on the hatchet plate **205** about its pivot shaft we can derive an expression for the incremental force on the hatchet latch, F_{latch}:

$$F_{latch}R_6 + F_S R_5 - F_R R_9 = 0$$

Substituting for F_R from the first equation we have:

$$F_{latch}R_6 + F_S\,(R_5 - (L_{lever}R_9/L_B)) = 0$$

Solving for the latch force we get:

$$F_{latch} = (F_S/R_6)((L_{lever}R_9/L_B) - R_5)$$

Wherein

F_S=the return spring force

R_6=the moment arm of the latch about the hatchet pivot =1.63"

L_{lever}=the length of the reset spring lever arm

R_9=the length from the hatchet pin assembly axis **206** to banana link first end **208** =1.25"

L_B=the length of the banana link =3.50"

R_5=the moment arm of the banana link **209** line-of force about the hatchet pin assembly axis **206**; which, in the preferred embodiment =0.117" when in the closed position and 0.55" when in the open position.

The opening reset latch force created by the reset spring **300** is, preferably, between about one and three lbs. The closing tripping latch force due to the reset spring **300** is, preferably, between about one and three lbs. However, in the preferred embodiment, the lever length is about 1.00 inch and the spring **300** force is about 10.0 lbs. Thus, in the preferred embodiment there is an opening force ($F_{latch,\ open}$=) of −1.2 lbs and a closing force ($F_{latch,\ closed}$=) of 1.5 lbs. This calculation illustrates that the load on the hatchet plate **205** reverses as the breaker closes. In the preferred embodiment, the latch "load" on the hatchet plate **205** is negative 1.2 pounds (resets) in the open position and in the closed position it reverses and becomes a positive 1.5 lbs. The corresponding vertical loads at the banana link **209** upper pin are 1.9 lbs upward and 1.6 lbs downward.

As shown in FIG. **12**, the offset member **312** may be a separate, elongated, planar member **320** that is coupled to the banana link **209**. In this embodiment, the member **320** has a perpendicular tab **322**. Thus, when the member **320** is disposed adjacent to the banana link **209**, the perpendicular tab **322** extends over and engages the banana link **209**. In the preferred embodiment, as shown in FIG. **8**, the offset member **312** is simply incorporated into the banana link **209**.

While specific embodiments of the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. For example, the circuit breaker **1** described above is structured so that the banana link **209** has the eponymous "banana" shape. However, a circuit breaker with a different layout may have a straight link, or an link of another shape, as required. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of invention which is to be given the full breadth of the claims appended and any all equivalents thereof.

What is claimed is:

1. A spring offset device structured to extend between a circuit breaker frame assembly and a trip mechanism, said trip mechanism having a banana link and hatchet plate, said frame assembly supporting a hatchet pin assembly, said banana link being an elongated member having a first end and a second end, said second end coupled to said hatchet plate, said hatchet plate being pivotally mounted on said hatchet pin assembly and structured to move between a closed position, an open position, and a reset position, said banana link also structured to move with said hatchet plate into a corresponding closed position, a open position, and a reset position, said spring offset device comprising:

an offset member disposed on said banana link;

a spring anchor disposed on said frame assembly, said spring anchor spaced from said hatchet pin assembly;

a spring extending between said offset member and said spring anchor;

wherein said offset member and said spring anchor are structured so that when said hatchet plate is in said closed position, said spring creates an opening force on said hatchet plate biasing said hatchet plate toward the open position, and when said hatchet plate is in the reset position, said spring creates a closing force on said hatchet plate biasing said hatchet plate toward said reset position.

2. The spring offset device of claim **1** wherein:

said hatchet plate is structured to move within a plane;

said hatchet pin assembly has an axis of rotation that extends generally perpendicular to said hatchet plate plane of movement;

said spring has a longitudinal axis; and

wherein when said spring longitudinal axis remains on a single side of said hatchet pin assembly axis as said banana link moves between said closed position, said open position, and said reset position.

3. The spring offset device of claim **1** wherein said offset member is disposed on said banana link adjacent said first end.

4. The spring offset device of claim **3** wherein said offset member is incorporated into said banana link.

5. The spring offset device of claim **3** wherein said offset member is coupled with said banana link.

6. The spring offset device of claim **5** wherein:

said banana link is a planar member; and

said offset member is an elongated, planar member having a perpendicular tab, said offset member being disposed adjacent to said banana link so that said perpendicular tab engages said banana link.

7. A circuit breaker comprising:

a housing with an internal frame assembly;

at least one pair of main contacts disposed in said housing, said contacts structured to move between a first, open position and a second, closed position;

an operating mechanism coupled to said at least one pair of main contacts and structured to separate said at least one pair of main contacts, said operating mechanism including a trip mechanism;

said tripping mechanism having a trip mechanism banana link, a hatchet plate, a hatchet pin assembly; and a spring offset device;

said hatchet pin assembly coupled to said frame assembly;

said operating mechanism structured to create a tripping torque on said hatchet plate;

said banana link being an elongated member having a first end and a second end, said second end coupled to said hatchet plate;

said hatchet plate being pivotally mounted on said hatchet pin assembly and structured to move between a closed position, an open position, and a reset position;

said banana link structured to move with said hatchet plate into a corresponding closed position, an open position, and a third reset position;

said spring offset device having an offset member disposed on said banana link, a spring anchor disposed on said frame assembly, said spring anchor spaced from said hatchet pin assembly, and a spring extending between said offset member and said spring anchor; and

wherein said offset member and said spring anchor are structured so that when said hatchet plate is in said closed position, said spring creates an opening force on said hatchet plate biasing said hatchet plate toward the open position, and when said hatchet plate is in the reset position, said spring creates a closing force on said hatchet plate biasing said hatchet plate toward said closed position.

8. The circuit breaker of claim **7** wherein:

said hatchet plate is structured to move within a plane;

said hatchet pin assembly has an axis of rotation that extends generally perpendicular to said hatchet plate plane of movement;

said spring has a longitudinal axis; and wherein when said spring longitudinal axis remains on a single side of said hatchet pin assembly axis as said banana link moves between said closed position, said open position, and said reset position.

9. The circuit breaker of claim **7** wherein said operating mechanism is structured to create a tripping torque that is greater than the torque created by said spring force when said hatchet plate is in said closed position and wherein said spring offset device is structured to create a reset torque greater than said tripping torque when said hatchet plate is in reset position.

10. The circuit breaker of claim **7** wherein said opening force is between about 1 and 3 lbs.

11. The circuit breaker of claim **10** wherein said closing force is between about 1 and 3 lbs.

12. The circuit breaker of claim **11** wherein said closing force is about 1.5 lbs.

13. The circuit breaker of claim **7** wherein said opening force is about 1.2 lbs.

14. The circuit breaker of claim **7** wherein said closing force is between about 1 and 3 lbs.

15. The circuit breaker of claim **7** wherein said closing force is about 1.5 lbs.

16. The circuit breaker of claim **7** wherein said offset member is disposed on said banana link adjacent said first end.

17. The circuit breaker of claim **16** wherein said offset member is incorporated into said banana link.

18. The circuit breaker of claim **16** wherein said offset member is coupled with said banana link.

19. The circuit breaker of claim **18** wherein:

said banana link is a planar member; and

said offset member is an elongated, planar member having a perpendicular tab, said offset member being disposed adjacent to said banana link so that said perpendicular tab engages said banana link.

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